Physics 131
General Physics I
Grinnell College

Homework IX-XI

Session IX.2

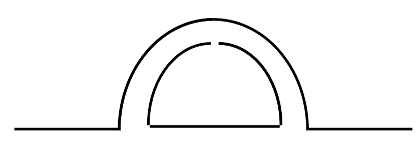
1. Recall that you discovered that diffraction through multiple slits gave maxima at angles described by

$$d\sin(\theta_m) = m\lambda.$$

Our cardboard mounted diffraction gratings have a line spacing of 600 lines per mm. What is the largest m value that allows a transmission spot with our 633 nanometer wavelength lasers? In other words, given θ must be less than 90˚ for the light to get through the grating; what is the largest m that still satisfies this?

2. Sound gets around corners easily because of diffraction effects. Sound travels at 300 m/sec. Which pitches will get around corners more easily, low pitches (low frequencies) or high pitches (high frequencies)? Explain. The ability to get around corners will reflect whether the wavelength is large or small relative to typical openings, such as doorways. If a doorway opening is about 1 m, this "critical wavelength" is also about 1 m. What frequency does this correspond to?

3. Sound is traveling through a tube that splits and then recombines, as shown below. The difference in path between the two sides is 20 cm. What is the lowest frequency at which you would expect to experience destructive interference at the far end?



Session X.1

4. Consider a single photon of red laser light, with wavelength of 633 nm (nano is 10^{-9}). What energy does this carry? What momentum? How does the energy compare to typical atomic energies of a few times 10^{-19} J?

5. Now consider an electron with a kinetic energy of 5×10^{-19} J (typical atomic energies). What is the wavelength of this electron? How does this compare to the photon wavelength in problem 8, and typical atom/molecule sizes of 1 nm?

Session XI.1

6. The quantum wavelength of familiar objects are very small. Reconsider a recent problem of the Day: a 200 g baseball, which pitchers can throw at up to100 mi/hr (45 m/sec).

a. How fast would the baseball have to move to give it a wavelength roughly the size of the ball, that is about 10 cm?

b. If the baseball did move at 45 m/sec, what mass would it need to have to give it a wavelength of 10 cm?

7. We had seen a general form for a one dimensional wave represented mathematically as

$$y(x,t) = A\sin(kx - \omega t)$$

Consider the quantum color analogy. What properties of the color wave correspond to A, k, and ω? Describe each in a few words.